PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01L

A2

(11) International Publication Number: WO 99/65061

(43) International Publication Date: 16 December 1999 (16.12.99)

(21) International Application Number: PCT/SG99/00053

(22) International Filing Date: 3 June 1999 (03.06.99)

(30) Priority Data:
9801257-8 8 June 1998 (08.06.98) SG

(71) Applicants *(for all designated States except US)*: ADVANCED SYSTEMS AUTOMATION LIMITED [SG/SG]; 54 Serangoon North Avenue 4, Singapore 555854 (SG). DATA STORAGE INSTITUTE [SG/SG]; 10 Kent Ridge, Singapore 119260 (SG).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: LU, Yongfeng [SG/SG]; 21 Blk 287D Jurong East Street, #08-310, Singapore 604287 (SG). SONG, Wendong [CN/SG]; 1 Blk 488 Jurong West Avenue, #11-137, Singapore 640488 (SG). CHEN, Qiong [CN/SG]; Blk 511 West Coast Drive, #09-333, Singapore 120511 (SG). JASON, Sim, Yak, Hui [SG/SG]; Blk 99 Aljunied Crescent, #10-387, Singapore 380099 (SG).

(74) Agent: LAWRENCE Y. D. HO & ASSOCIATES; Thongsia Building, 30 Bideford Road, #07-01, Singapore 229922 (SG).

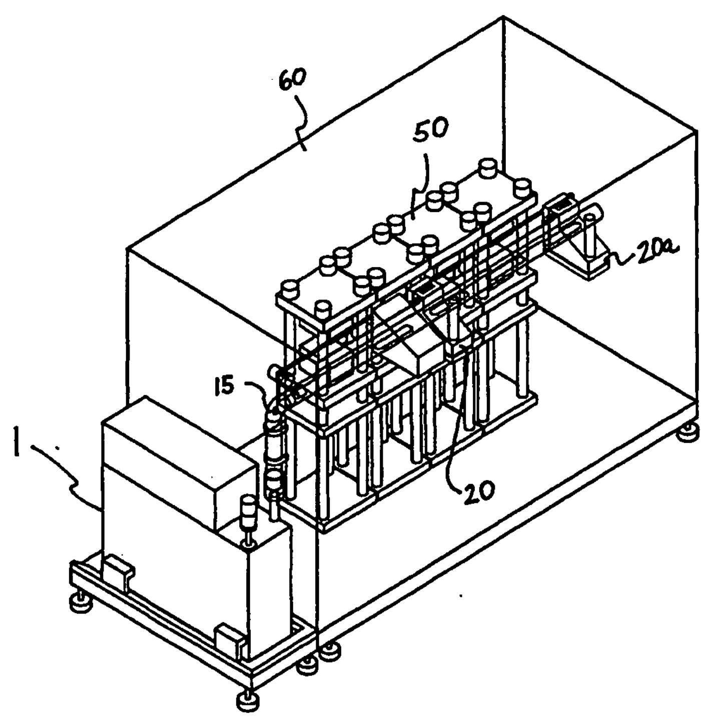
(81) Designated States: CN, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: A PORTABLE LASER CLEANING DEVICE FOR SEMICONDUCTOR PACKAGING MACHINES

(57) Abstract

A portable laser cleaning device which can be steered next to any semiconductor encapsulating tool having multiple moulds in one or more presses. The cleaning device basically includes a base, laser generator, optical pipe, and cleaning head. The laser generator fixedly rests on the base which is firmly attached to the encapsulating tool. The optical pipe is fixed within the encapsulating tool and delivers a beam of laser to the cleaning head. The cleaning head moves on a rail and precisely delivers the beam onto the surface of the mould to remove substantially all of the surface contaminants associated with semiconductor packaging.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

A PORTABLE LASER CLEANING DEVICE FOR SEMICONDUCTOR PACKAGING MACHINES

FIELD OF THE INVENTION

The present invention relates generally to the field of semiconductor packaging, and in particular, to a laser cleaning method and device for removing surface contaminants on moulds used in semiconductor packaging tools.

BACKGROUND OF THE INVENTION

The process for packaging semiconductor devices is well known to those skilled in the art. Generally speaking, the process typically involves placing a chip-carrying substrate between two mould halves, closing the mould halves, and injecting a type of resin material under intense heat and pressure to liquefy and cure the resin material. This is a high-volume process in the sense that a large number devices are typically processed in a relatively short time.

The encapsulation process often leaves surface contaminants on the surface of the moulds which can get quite heavy after several hours of continuous running of the packaging tool. These contaminants can be grease, wax, and residual resin. Because the encapsulation process occurs under intense heat and pressure, the contaminants adhere firmly to the surface such that the removal of the contaminants becom an xtremely difficult task.

Consequently, the removal of th se surfac contaminants is an involved process. Currently, the cleaning of the moulds is accomplished by injecting a substance called malamine into the empty moulds, exposing it to intense heat and pressure to liquefy the substance, and then letting it solidify. During this process, the contaminants react with the malamine compound and bond to its surface of the solidified malamine compound. Once solidified, the malamine compound is thrown out.

Although this is an established method of mould cleaning which is used extensively in the industry, it has a number of shortcomings. For one, it is time consuming; the whole process can take more than two hours. In an industry where high-volume production is of paramount importance, this expenditure of time can be quite costly. Moreover, the cleaning process is not complete in that even after the process, some residual contaminants remain. These residues can be detrimental to the encapsulation process as they may lead to defective packages. Furthermore, the cleaning material, malamine, releases toxic fumes which are harmful to human beings. Hence a careful handling of the malamine material is necessary to minimize danger.

For these reasons, there is a great need in the industry to have an effective cleaning process. Ideally, such a process should be implemented in a portable device which can move from one machine to another, one which can clean multiple moulds in a machine in a precise manner, and one which requires minimal docking and aligning time.

OBJECT OF THE INVENTION

Therefore, it is the object of the present invention to provide a laser cleaning device which is portable, precise, efficient and flexible.

SUMMARY OF THE INVENTION

The present invention utilizes laser to remove the surface contaminants such as grease, wax, and resin residue from a mould used in semiconductor packaging tools. Generally, the contaminant removal process utilizing the laser involves shooting a beam of laser onto the surface of the mould having the contaminants. The laser is delivered as a pulse which last only a short duration, e.g., 23 nanoseconds (ns). Multiple pulses may be required to completely remove the contaminants. Because the area of coverage for each pulse is usually much smaller than the total area of the mould surface, the laser beam needs to be moved around until the entire mould surface has been exposed to the laser. Because fumes are produced as the laser disintegrates the contaminants, some type of vacuum should be used to remove the residual gas and other debris.

To successfully use the laser process, a number of factors should be considered in producing an optimal result. For one, the process should be relatively fast--that is, the laser should not take an inordinate time to remove the surface contaminants. The removal process should also be complete--that is the laser should remove all or substantially all of the surface contaminants. In addition, the removal process should be non-invasive--that is, it should not damage the mould surface in any substantial way.

To produce th optimal result, a number of laser paramet rs must b controll d. Th se param t rs are, for xampl : type of las r, power output, wavelength of the laser, type of laser delivery (pulse or continuous), etc. For the present device, while there exists many laser types, it is preferable to utilize a laser which produces a pulse laser beam having a homogeneous energy profile, and which is non-coherent. These conditions allow for higher peak power, better control of the laser beam and thus a better contaminant removal process. It has been shown that KrF excimer laser has such properties, and thus, is a preferred laser type, though other laser types may carry these properties as well. Also, it is preferred that the laser pulse carry a pulse width of 23 ns (nanoseconds).

To successfully remove the contaminants, the laser beam must have sufficient power at a particular wavelength. For laser applications, power is defined in terms of fluence which is defined as energy divided by area where the units are mJ/cm^2. The wavelength is typically measured in nano-meters or "nm" for short. Although a range of wavelengths is certainly possible, the preferred wavelength is 248 nm. Similarly, while a range of power output is possible, the preferred power output is 300 mJ/cm^2.

It is important not to use a power output which may damage the mould surface beneath the contaminants. The amount of power required to cause damage depends partly on the wavelength of the laser and the type and nature of the material being hit by the laser.

In the preferred setting, i.e., KrF excimer laser with a wavelength of 248 nm, a pulse width of 23 ns, a pulse area of coverage of 1 cm^2, and a fluence level of 300 mJ/cm^2, it takes at least two pulses at the same location to ensur compl t removal of the contaminant lay r within the area of

cov rag . The contaminant lay r is typically about 1 to 2 μm in thickness. The 1 to 2 μm contaminant depth was formed from continuous running of the encapsulating tool for a period of about 24 hours. Where the tool is left to run for a longer period, the thickness of the contaminant layer would, of course, increase. To account for the different thickness of the contaminant layer, either the pulse width or the number of pulses per area or a combination of both needs to be modified, though a change in some of the other parameters may also work.

Taking the 1 to 2 μm thickness as an example, the entire mould surface (which has a surface area of about 468 cm^2), can be cleaned in about 2 to 3 minutes using the process parameters described above. However, to decrease the total time for the cleaning, the pulse area of coverage can be increased. The pulse area of coverage is basically determined by the size of the laser beam; the larger the size, the larger the area covered by each pulse.

Because the mould surface has various cavities for receiving a semiconductor device and for delivering the resin, the mould surface is not completely flat. At times, particularly if the size of the laser beam is quite large, the laser pulse may simultaneously expose two or more surfaces of different depths. Although the laser energy level is generally uniform over a distance, the focus length may facilitate a difference in the laser energy levels for the different depth. This difference can be significant where the focus length is very small. To avoid this problem, it is preferable have a very long focus length and to use a collimated beam.

Th cavities on the moulds create one additional probl m for th laser cleaning process. It is typical for the cavities to have side walls which

are p rp ndicular to th main surfac of the mould. If th las r were to b shot perp ndicular to the surface of th mould, th sid walls would not receive enough energy from the laser beam, as the beam would essentially be parallel to the side walls. To avoid this problem, it is preferred that the laser beam be shot at an angle to the mould surface. This way, all surfaces can receive sufficient energy from the laser.

In the preferred embodiment of the present invention, the laser cleaning process is implemented as a portable device which can be steered next to any semiconductor encapsulating tool having multiple moulds in one or more presses. The present device is not a completely standalone device in the sense that some of the components of the device need to be initially aligned and fixed to the encapsulating tool before the cleaning process is initiated.

The cleaning device basically includes a base, laser generator, optical pipe, and cleaning head. The base has foot pads which can be adjusted for height. The base is fixed to the encapsulating tool.

The optical pipe is positioned inside the semiconductor packaging machine and adjacent to the presses having the moulds. The function of the optical pipe is to guide the laser beam to the cleaning head through the use of mirrors. A plurality of slits are provided for delivering the laser beam to the cleaning head. Because the laser beam needs to travel a relatively long distance, a beam collimator is provided to collimate the beam.

The cleaning head has a laser tube which can be raised and lowered and is raised into the slit when the cleaning head is in positioned to r c iv the laser b am. The cl aning head has a lower block which can mov out to position itself in b tw n the moulds. Mirrors are provid d for

guiding th laser beam. The movement of the lower block is facilitat d by a s rvo motor. Th cl aning h ad is attached to a rail and can slid along the rail in a controlled manner with the use of a servo motor.

The present device has several advantages over a completely standalone laser cleaning device. By placing the optical pipe within the encapsulating tool, the housing for the laser generator can be made very small and portable. Also, once the optical pipe is installed and properly aligned, no additional alignment is necessary except to place the laser generator properly onto the base. Once, the laser generator is fixed onto the base, the laser cleaning device can clean each of the moulds without having to align itself for each mould set in a press. Hence, it significantly reduces docking and alignment time. A standalone device would have to align itself for each press.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective diagram of the preferred embodiment of the present laser cleaning device which is placed adjacent to a semiconductor encapsulating machine showing the presses.

FIG. 2 is the same diagram as FIG. 1 with the presses removed from the diagram for easy viewing.

FIG. 3 is a perspective diagram of the preferred embodiment of the present laser cleaning device which is placed adjacent to a semiconductor encapsulating machine with th las r generator shown in phantom lines.

FIG. 4 is a perspective diagram of th laser cl aning head shown in isolation to illustrate how it positions itself in relation to th moulds.

FIG. 5 is an Auger Electron Spectroscopy (AES) spectrum graph illustrating the depth profile of a contaminant layer typically found on moulds used in semiconductor packaging machines before undergoing the laser cleaning process of the present invention.

FIG. 6 is an Auger Electron Spectroscopy (AES) spectrum graph illustrating the depth profile of a contaminant layer typically found on moulds used in semiconductor packaging machines after undergoing the laser cleaning process of the present invention.

FIG. 7 is an Auger Electron Spectroscopy (AES) spectrum graph illustrating the depth profile of a contaminant layer typically found on moulds used in semiconductor packaging machines after undergoing the laser cleaning process of the present invention for one continuous hour.

DETAILED DESCRIPTION OF THE INVENTION

The present invention utilizes laser to remove the surface contaminants such as grease, wax, and resin residue from a mould used in semiconductor packaging tools. Generally, the contaminant removal process utilizing the laser involves shooting a beam of laser onto the surface of the mould having the contaminants. The laser is delivered as a pulse which last only a short duration, e.g., 23 nanoseconds (ns). Multiple puls s may be r quired to compl t ly remove th contaminants. Because th ar a of coverag for each puls is usually much small r than th total

area of th mould surface, the las r b am needs to b mov d around until the ntire mould surface has been exposed to th las r. Because fumes are produced as the laser disintegrates the contaminants, some type of vacuum should be used to remove the residual gas and other debris.

To successfully use the laser process, a number of factors should be considered in producing an optimal result. For one, the process should be relatively fast--that is, the laser should not take an inordinate time to remove the surface contaminants. Although the speed of removal can vary depending on the parameters which are chosen for the laser, preferably, the parameters should be selected such that the duration required to remove all of the contaminants from a single mould half (either bottom or top half) should be no more than 5 minutes.

The removal process should also be complete--that is the laser should remove all or substantially all of the surface contaminants. The level of completeness required, of course, depends on the process specification. In addition, the removal process should be non-invasive--that is, it should not damage the mould surface in any substantial way. For instance, the mould surface typically has a chrome coating over a steel substrate, and it is important that the laser beam does not cause the peeling of this coating or damage the underlying substrate. And lastly, the process should be relatively safe to the people operating the laser cleaning device.

To produce the optimal result, a number of laser parameters must be controlled. These parameters are, for example: type of laser, power output, wav l ngth of the laser, typ of laser d liv ry (puls or continuous), etc. For th present device, while th r xists many laser types, it is preferabl

to utilize a las r which produces a puls las r b am having a homog neous nergy profil , and which is non-coher nt. These conditions allow for higher peak power, better control of the laser beam and thus a better contaminant removal process. It has been shown that KrF excimer laser has such properties, and thus, is a preferred laser type, though other laser types may carry these properties as well. Also, it is preferred that the laser pulse carry a pulse width of 23 ns (nanoseconds).

Experiments have shown that at least one type of laser may not be optimal for the removal of contaminants on a mould surface. For instance, an experiment using a YAG laser, a beam having a wavelength of 532 nm and another beam having a wavelength of 1064 nm, both having a pulse width of 7 nano-second, did not produce optimal results because the laser beams, while did remove the surface contaminants, tended to easily damage the mould surface, a highly undesirable result.

To successfully remove the contaminants, the laser beam must have sufficient power at a particular wavelength. For laser applications, power is defined in terms of fluence which is defined as energy divided by area where the units are mJ/cm^2. The wavelength is typically measured in nano-meters or "nm" for short. Although a range of wavelengths is certainly possible, the preferred wavelength is 248 nm. Similarly, while a range of power output is possible, the preferred power output is 300 mJ/cm^2.

Choosing the proper wavelength and power output is important, and several factors must be taken into consideration. For the wavelength, it should short enough that there is sufficient energy absorption by the contaminant material. For th present application, it has be n found that 248 nm was suffici nt. For th power output, th pow r should exceed the

minimum thr shold for r moving th contaminants. This threshold dep nds mainly on th chemical composition of the contaminants. For the types of contaminants typically found in mould surfaces of semiconductor packaging tools, e.g., grease, wax, resin residues, which are usually carbon-based, the threshold was generally found to be around 150 mJ/cm^2 at the wavelength of 248 nm.

The minimum power output, however, while sufficient for removing the contaminants, may not be optimal because the rate of removal may be slow or the removal process may not be complete, that is, some residue may be left over and hence many pulses may be required for a complete removal. Hence, it may be desirable to operate the laser at a higher than the minimum threshold to speed up the process. In addition, the removal performance can be increased by using a shorter wavelength for the laser, and thus, increasing the amount of laser absorption.

Although higher power may increase the removal rate and therefore generally desirable, it is equally important not to use a power output which may damage the mould surface beneath the contaminants. Again, the amount of power required to cause damage depends partly on the wavelength of the laser and the type and nature of the material being hit by the laser. In the case of moulds being used in the semiconductor packaging industry, it is typically for the moulds to have a 2 to 3 μm chrome coating over a steel substrate. A common material for the substrate is AST powder high speed steel. For this situation, it is very important that the laser does not cause any degradation in the chromium coating or in the steel substrat itself. It is particularly important that the cl aning proc ss does not cause the chromium coating to peel.

Two important conc pts in analyzing pow r output as relat d the possiblity of damag to th underlying mat rial are thermal diffusion length μ and temperature rise ΔT on the surface of the mould, both of which are well-known concepts to those skilled in the art. It was determined empirically that μ in the present case was 1.42 μm which is less than the thickness of the chromium coating. Generally, it is desirable to have a low μ, and particularly in this case, it is preferable that μ does not exceed the thickness of the chromium coating.

The difference in the thermal expansion between the chromium coating and the underlying substrate steel generally becomes significant after an average temperature rise of over 400 degree Celsius, and hence, it is desirable to avoid a power output of the laser which will cause a temperature rise exceeding this level. A laser fluence of 200 mJ/cm^2 with pulse width of 23 ns resulted in an average temperature rise of 175 degrees Celsius, and a laser fluence of 300 mJ/cm^2 at the same pulse width resulted in an average temperature rise of 227 degrees Celsius, both below the undesirable level of 400 degree rise. Although the precise output level which would cause a temperature rise of 400 degrees Celsius is not known with certainty, it is believed that damage to the mould surface may occur at the fluence level of about 1500 mJ/cm^2.

In the preferred setting, i.e., KrF excimer laser with a wavelength of 248 nm, a pulse width of 23 ns, a pulse area of coverage of 1 cm^2, and a fluence level of 300 mJ/cm^2, it takes at least two pulses at the same location to ensure complete removal of the contaminant layer within the area of cov rage. Th contaminant lay r is typically about 1 to 2 μm in thickness. The 1 to 2 μm contaminant d pth was form d from continuous running of

th ncapsulating tool for a p riod of about 24 hours. Wh r th tool is l ft to run for a longer period, the thickn ss of the contaminant layer would, of course, increase. To account for the different thickness of the contaminant layer, either the pulse width or the number of pulses per area or a combination of both needs to be modified, though a change in some of the other parameters may also work. For instance, if the contaminant layer is twice as thick, i.e. 4 μm, the pulse width may need to be doubled, or possibly, four, instead of two, pulses may be needed. However, because the process is not entirely linear, it may not always be true that the doubling of the thickness of the contaminant layer necessary requires doubling of the process parameter. Hence, some experiment may be needed to find an optimal pulse width and/or number of pulses which is required for effective removal of the contaminant layer in a given area of coverage.

Taking the 1 to 2 μm thickness as an example, the entire mould surface (which has a surface area of about 468 cm^2), can be cleaned in about 2 to 3 minutes using the process parameters described above. However, to decrease the total time for the cleaning, the pulse area of coverage can be increased. The pulse area of coverage is basically determined by the size of the laser beam; the larger the size, the larger the area covered by each pulse. However, because fluence is defined as laser energy divided by surface area, increasing the area of coverage per pulse requires the increase in the laser energy per pulse if the same fluence is to be maintained. Depending on how large the area of coverage is, a more powerful laser generator may be required. Of course, another way to decrease the cleaning time is to simply have multiple laser beams shooting

at different areas, though this may require multiple las r g nerators and/or a more pow rful las r which can be split into multiple b ams.

Because the mould surface has various cavities for receiving a semiconductor device and for delivering the resin, the mould surface is not completely flat. At times, particularly if the size of the laser beam is quite large, the laser pulse may simultaneously expose two or more surfaces of different depths. Although the laser energy level is generally uniform over a distance, the focus length may facilitate a difference in the laser energy levels for the different depth. This difference can be significant where the focus length is very small. To avoid this problem, it is preferable have a very long focus length and to use a collimated beam. As an illustration, a typical mould can have a cavity which is about 5 mm in depth. If a focus length of 150 mm is chosen, the difference in the energy delivered to the different depths would be only around 6.8 % which would be an acceptable difference. Of course, this difference can be further reduced by having a even larger focus length.

The cavities on the moulds create one additional problem for the laser cleaning process. It is typical for the cavities to have side walls which are perpendicular to the main surface of the mould. If the laser were to be shot perpendicular to the surface of the mould, the side walls would not receive enough energy from the laser beam, as the beam would essentially be parallel to the side walls. To avoid this problem, it is preferred that the laser beam be shot at an angle to the mould surface. This way, all surfaces can receive sufficient energy from the laser. Although the angling of the las r will slightly increas th area of cov rage for each las r pulse, this

will not be significant, or it can be rectifi d by increasing the n rgy lev l of th pulse.

FIGS. 5 through 7 demonstrate the effectiveness of this above described cleaning process. FIGS. 5 through 7 illustrate the Auger Electron Spectroscopy (AES) graphs which can be used to analyze the composition of materials at different depths. AES technology is generally well-known to those skilled in the art.

FIG. 5 is a graph illustrating the composition of an actual contaminant layer found on a mould surface having a chromium coating before the mould underwent the laser cleaning process. Each of the curves represents a particular depth below the surface of the top layer. Hence, a depth of 0 in this case would be the very top of the contaminant layer. The various peaks indicate the presence of a particular material; generally, the higher the peak, the greater the presence. The peaks marked "C" indicate the presence of carbon; the peaks marked "Cr" indicate the presence of chromium; the peaks marked "O" indicate the presence of oxygen in the form of oxide. Much of the contaminants found in semiconductor packaging tools carry carbon, and hence, high presence of carbon indicates high levels of contaminants. The presence of oxide is generally indicative of damage which may have occured on the surface of the chromium coating, as the laser can cause oxidation on this surface. Some oxide can also come from the contamination itself. The presence of chromium, on the other hand, is desirable since this is the coating material for the mould surface. As can be seen from the graph in FIG. 5, there is a high level of carbon almost up to a depth of 104 nm.

Compare graph in FIG. 5 to one in FIG. 6. FIG. 6 illustrat s th composition of the contaminant layer after undergoing the laser cl aning process. Note that a slight level of carbon can be found only at the very top of the layer, and the level drop signficantly even after only a few nanometers in depth. On the other hand, there is a high level of chromium through the entire layer. Some level of oxide is found only near the top layer, which indicates that there is no damage to the chroming surface but that oxide has been absorbed during the transportation of the mould from the cleaning stage to the measuring stage.

In the preferred embodiment of the present invention, the laser cleaning process is implemented as a portable device 1 which can be steered next to any semiconductor encapsulating tool 60 having multiple moulds in one or more presses 50, as illustrated in FIG. 1. The laser cleaning device 1 is better illustrated in FIG. 2 where the presses 50 (FIG. 1) have been removed so that the details of the device 1 can be better shown. The present device is not a completely standalone device in the sense that some of the components of the device need to be initially aligned and fixed to the encapsulating tool before the cleaning process is initiated.

In referring to FIG. 2, the cleaning device 1 basically includes a base 5, laser generator 10, optical pipe 15, and cleaning head 20. As shown better in FIG. 3, the base 5 has foot pads 6 which can be adjusted for height. The base 5 is fixed to the encapsulating tool.

Still referring to FIG. 3, sitting on top of the base 5 is the generator 10 which is shown in phantom lines so that the positional relationship b tw n the g n rator and th bas can be better s en. As can seen from FIG. 2,

the g n rator 10 sits within a depressed cavity such that the gen rator 10 is positioned precis ly in relation to th base 5. A pr cise male/female mating joint 7 aligns the base 5 in relation to the laser generator 10, and keeps the laser generator 10 from moving. The male 7b is fixed to the laser generator 10; the female 7a is fixed to the base 5. Additional reinforcements 8 are provided to ensure that the generator 10 does not deviate from its resting position. The laser generator 10 can be separated from the base 5 when it needs to be moved to a different location. A laser tube 11 for guiding the laser beam provides a means for precisely mating with the optical pipe 15.

Now referring to FIGS. 1 and 2, the optical pipe 15 is positioned inside the semiconductor packaging machine 60 and adjacent to the presses 50 having the moulds. The function of the optical pipe 15 is to guide the laser beam to the cleaning head through the use of mirrors. A plurality of slits 16 are provided for delivering the laser beam to the cleaning head 20. Because the laser beam needs to travel a relatively long distance, a beam collimator 17 is provided to collimate the beam to optimize the quality of the beam.

Now referring to FIG. 4, the cleaning head 20 has a laser tube 21 which can be raised and lowered as illustrated by the phantom lines. The laser tube is raised into the slit 16 when the cleaning head 20 is in positioned to receive the laser beam. When the tube 21 is inside the optical pipe 15, a mirror 26 (FIG. 2), which is attached to the tube 21, intercepts and redirects the beam into the tube 21 and to the mirror 23. The cl aning head 20 has a low r block 22 which can mov out to position itself in between th moulds 52 (see lower block 22a in phantom lin s). Mirrors

23 and 24 ar provided for guiding the las r b am 25. Th movem nt of the low r block 22 is facilitated by a servo motor (not shown). As shown in FIG. 2, the cleaning head 20 is attached to a rail 30 and can slide along the rail 30 in a controlled manner with the use of a servo motor 31 as indicated by the cleaning head 20a in phantom lines. Some encapsulating machines already come with a brush cleaning unit (here 40) which is also controlled by a servo motor and moves on a rail. For these machines, the servo motor 31 and the rail 30 can be shared with the laser cleaning head 20.

Before the cleaning operation can begin, it is important to align the device correctly. First, the male/female mating joint 7 should be aligned such that when the generator is placed onto the base 5, the laser tube 11 should fit precisely with the optical pipe 15. Also, the optical pipe 15 should be positioned such that the slits 16 are positioned correctly relative to the presses 50 so that the cleaning head 20 can properly place its lower block over the moulds. Some initial calibration may be required. In the preferred embodiment, the processes are fully automated and controlled by a software.

The present device has several advantages over a completely standalone laser cleaning device. By placing the optical pipe 15 within the encapsulating tool, the housing for the laser generator can be made very small and portable. Also, once the optical pipe 15 is installed and properly aligned, no additional alignment is necessary except to place the laser generator 10 properly onto the base 5. Once, the laser generator 10 is fixed onto the bas 5, the las r cl aning device 1 can clean each of th moulds without having to align itself for ach mould s t in a press. Hence,

it significantly reduces docking and alignment tim . A standalone d vice would hav to align its lf for ach press.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are, therefore, to be embraced therein.

CLAIMS

We Claim:

1. A device for removing surface contaminants from a mould used in semiconductor encapsulating machine comprising:

   a laser generator for generating a beam of laser;

   a means for fixedly supporting said laser generator adjacent to said encapsulating machine;

   an optical pipe for receiving and guiding said beam of laser, said optical pipe fixedly placed within said encapsulating machine; and

   a cleaning head for receiving said beam of laser from said optical pipe and precisely delivering said beam onto a surface of said mould;

   wherein said beam of laser is adapted for removing substantially all of the surface contaminants.

2. A device as claimed in Claim 1 wherein said means for supporting said laser is a base fixedly attached to said encapsulating machine, said base having a cavity for receiving said generator.

3. A device as claimed in Claim 2 further comprising a male/female mating joint to fix said laser generator to said base.

4. A device as claimed in Claim 1 wherein said cleaning head has a laser tube for receiving said beam from said optical pipe, said optical pipe having a slot for receiving said laser tube.

5. A device as claimed in Claim 1 wherein said cleaning head has a low r block, said low r block capable of precisely positioning itself relative to the mould.

6. A device as claimed in Claim 5 wherein said beam is collimat d.

7. A devic as claimed in Claim 5 wherein said cleaning head has a lower block, said lower block capable of precisely positioning itself relative to the mould.

8. A device as claimed in Claim 5 wherein said cleaning head moves on a rail.

9. A device as claimed in Claim 1 wherein said beam is collimated.

10. A device as claimed in Claim 4 wherein said beam is collimated.

11. The device as recited in claim 1 wherein said laser is a KrF excimer pulse laser.

12. The device as recited in claim 1 wherein said beam of laser is emitted between a power range of 149 and 301 mJ/cm^2.

13. The device as recited in claim 12 wherein said beam of laser is emitted at a wavelength of 248 nanometers.

14. The device as recited in claim 13 wherein said beam of laser has a pulse width of 23 nanoseconds.

15. The device as recited in claim 14 wherein said beam of laser is emitted at an angle to the surface of the mould.

16. The device as recited in claim 15 wherein an area of coverage is approximately 1 cm^2.

17. The device as recited in claim 16 wherein a total duration for removing all of the contaminants on the surface of the mould is less than 5 minutes.

18. The device as recited in claim 5 wherein said laser is a KrF excimer puls las r.

19. The devic as recit d in claim 18 wh rein said beam of laser is mitted betw en a power rang of 149 and 301 mJ/cm^2.

20. The device as recited in claim 19 wherein said beam of laser is emitted at a wavelength of 248 nanometers.

21. The device as recited in claim 20 wherein said beam of laser has a pulse width of 23 nanoseconds.

22. The device as recited in claim 21 wherein said beam of laser is emitted at an angle to the surface of the mould.

23. The device as recited in claim 22 wherein an area of coverage is approximately 1 cm^2.

24. The device as recited in claim 23 wherein a total duration for removing all of the contaminants on the surface of the mould is less than 5 minutes.

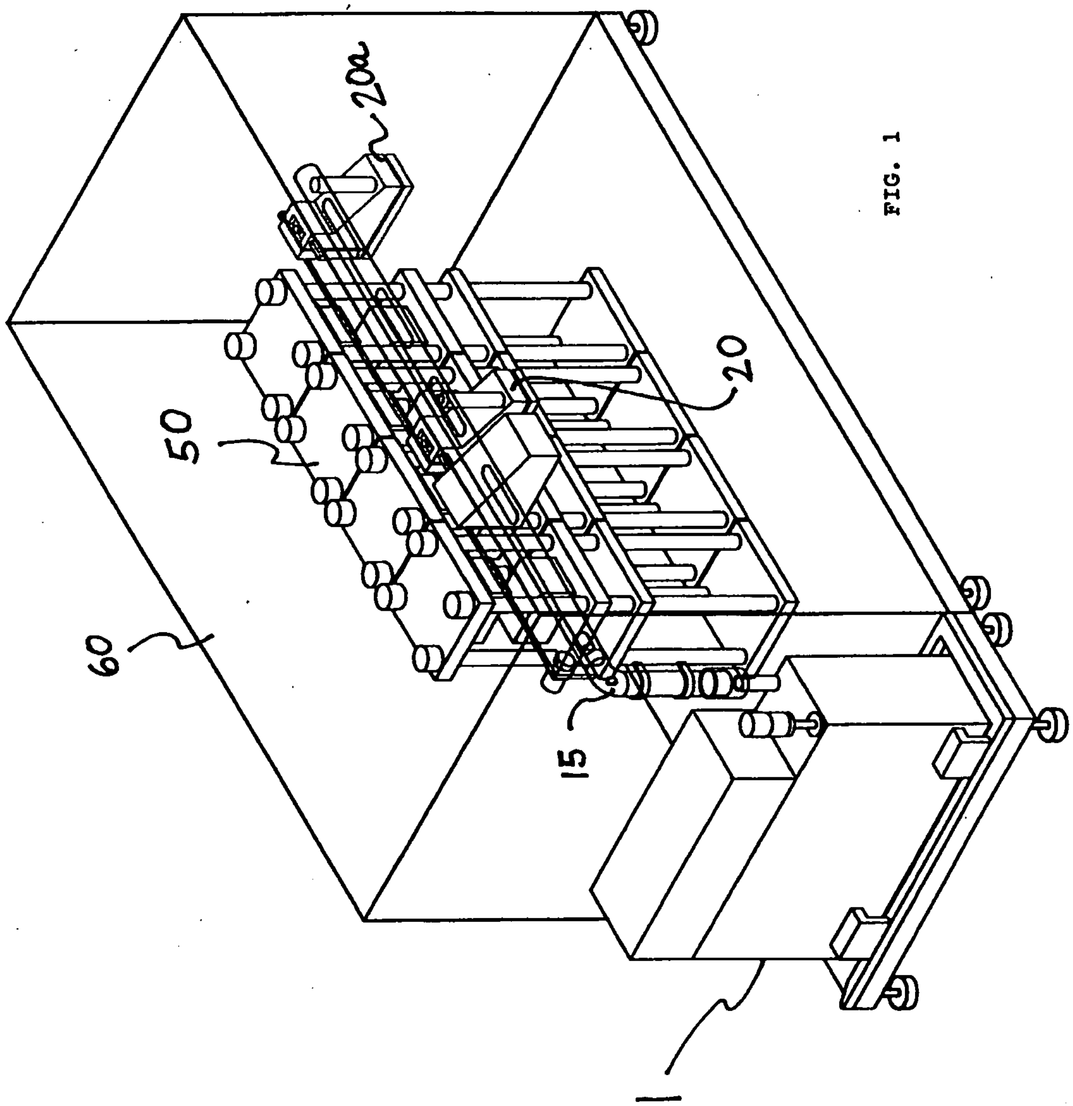


FIG. 1

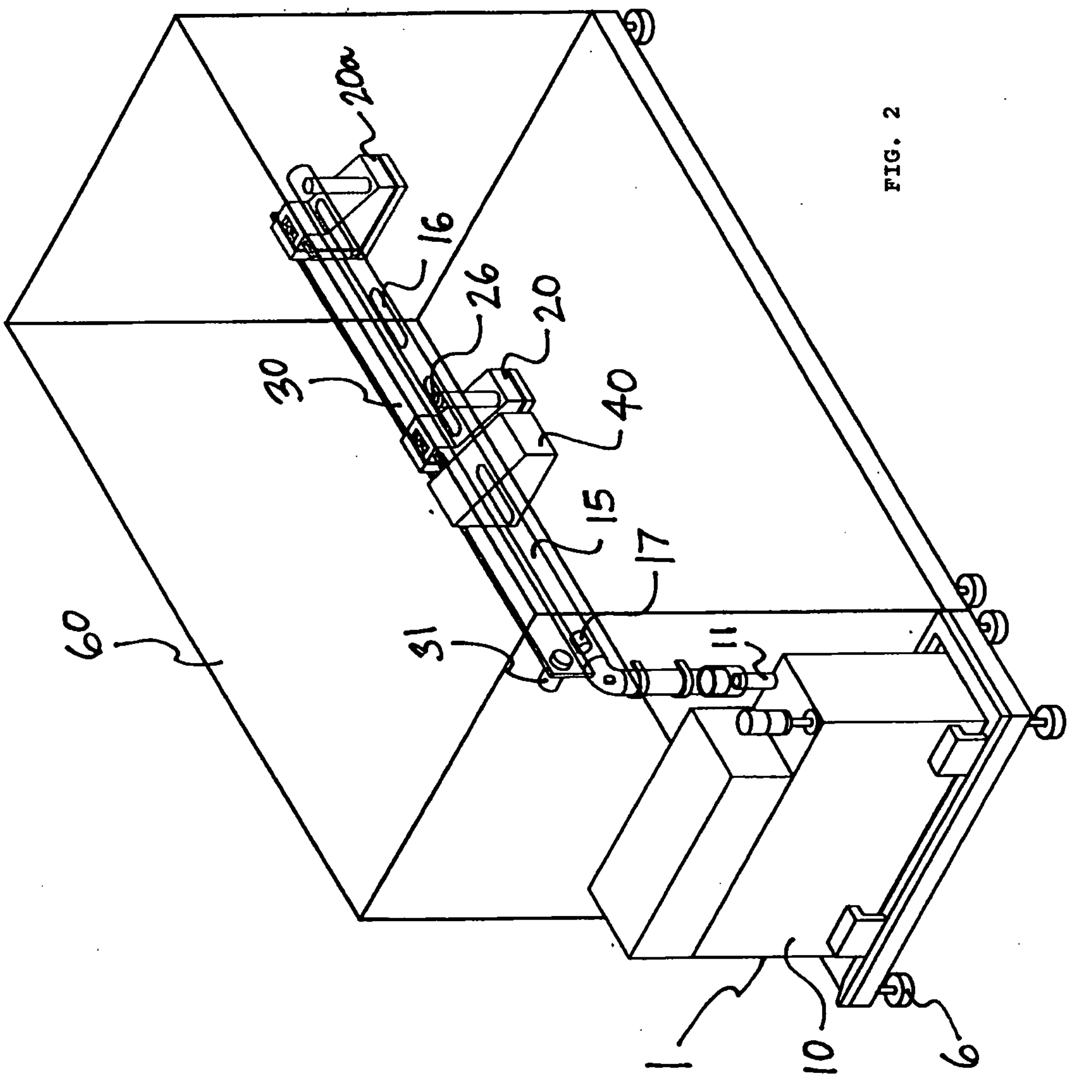


FIG. 2

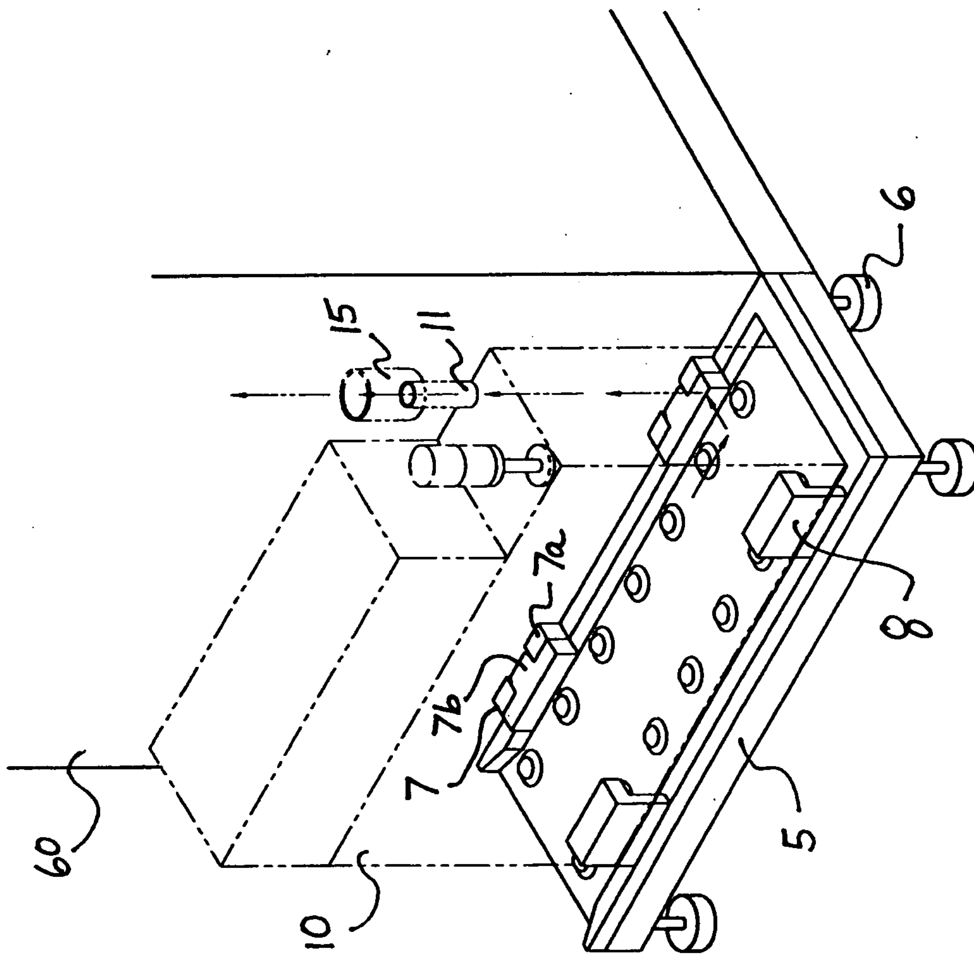


FIG. 3

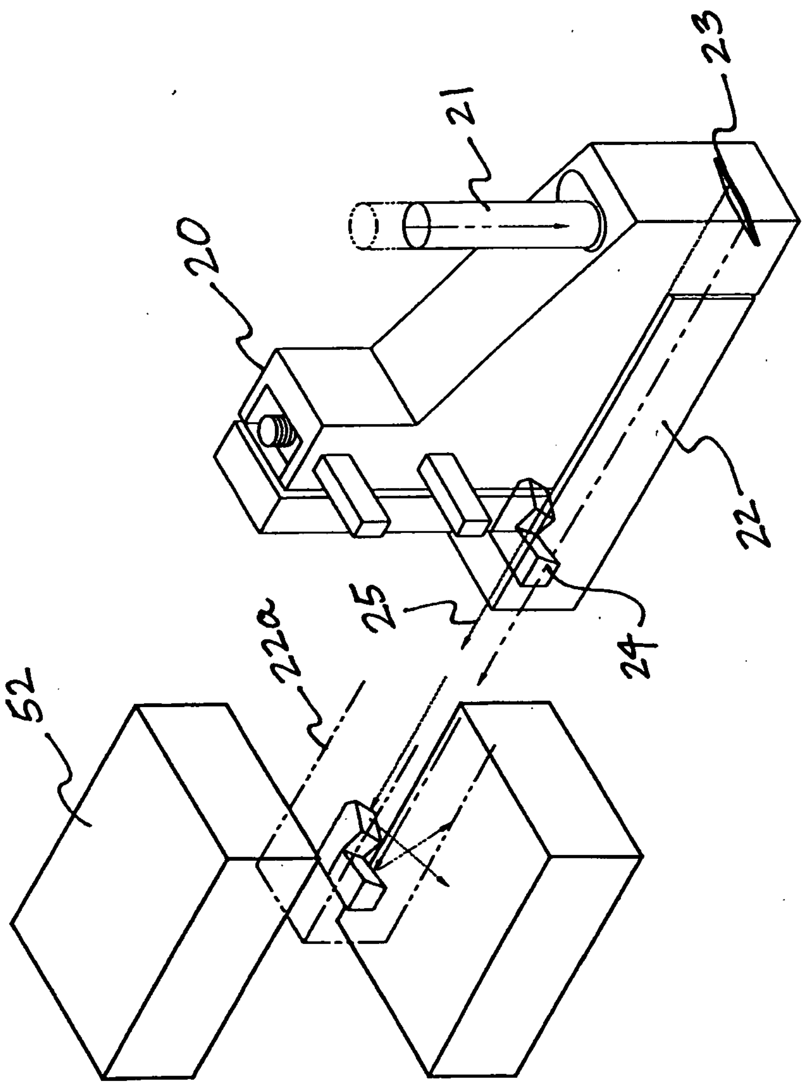


FIG. 4

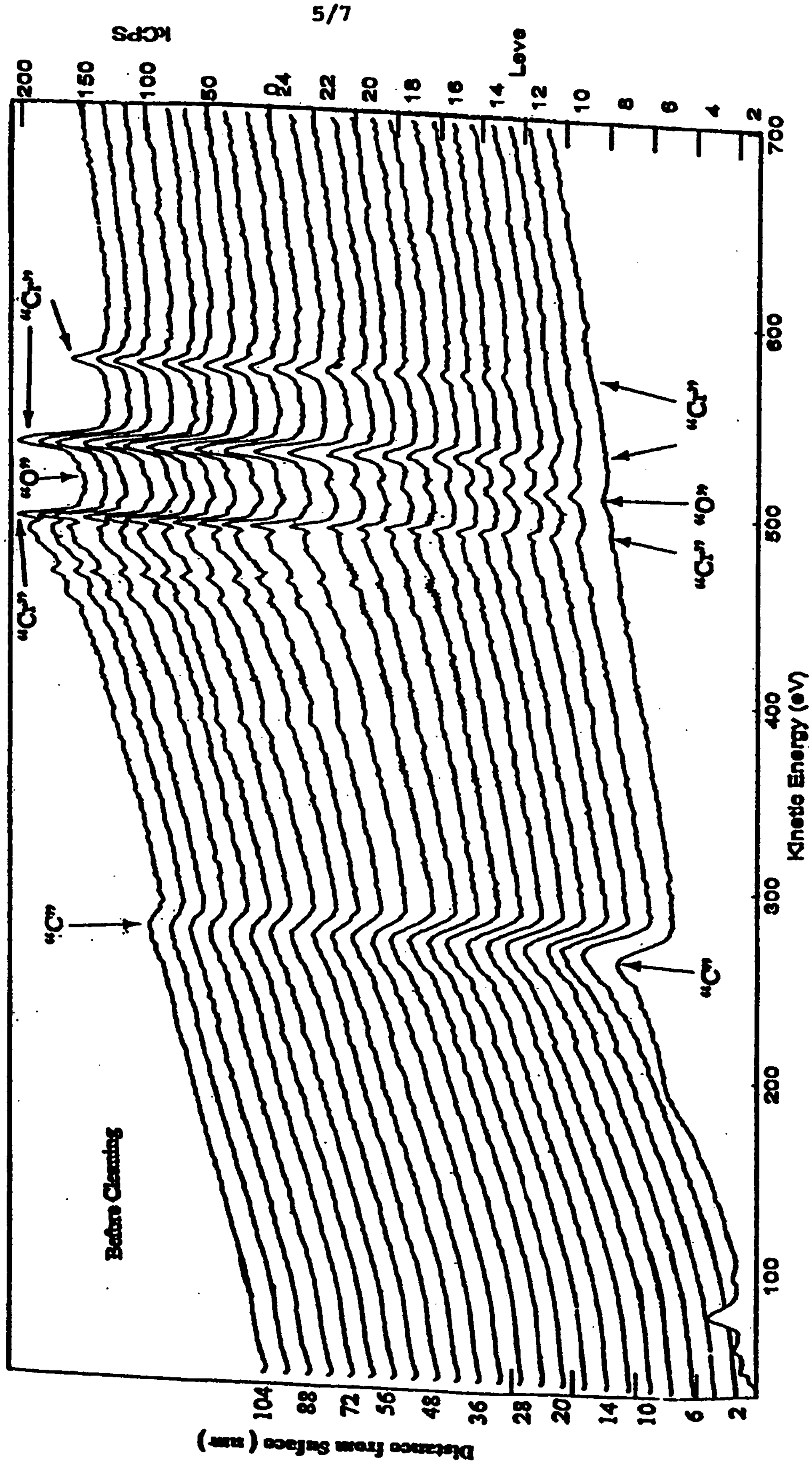

kCPS
Leve
Before Cleaning
“Cr”
“O”
“C”
Kinetic Energy (eV)
Distance from Surface (nm)

FIG. 5

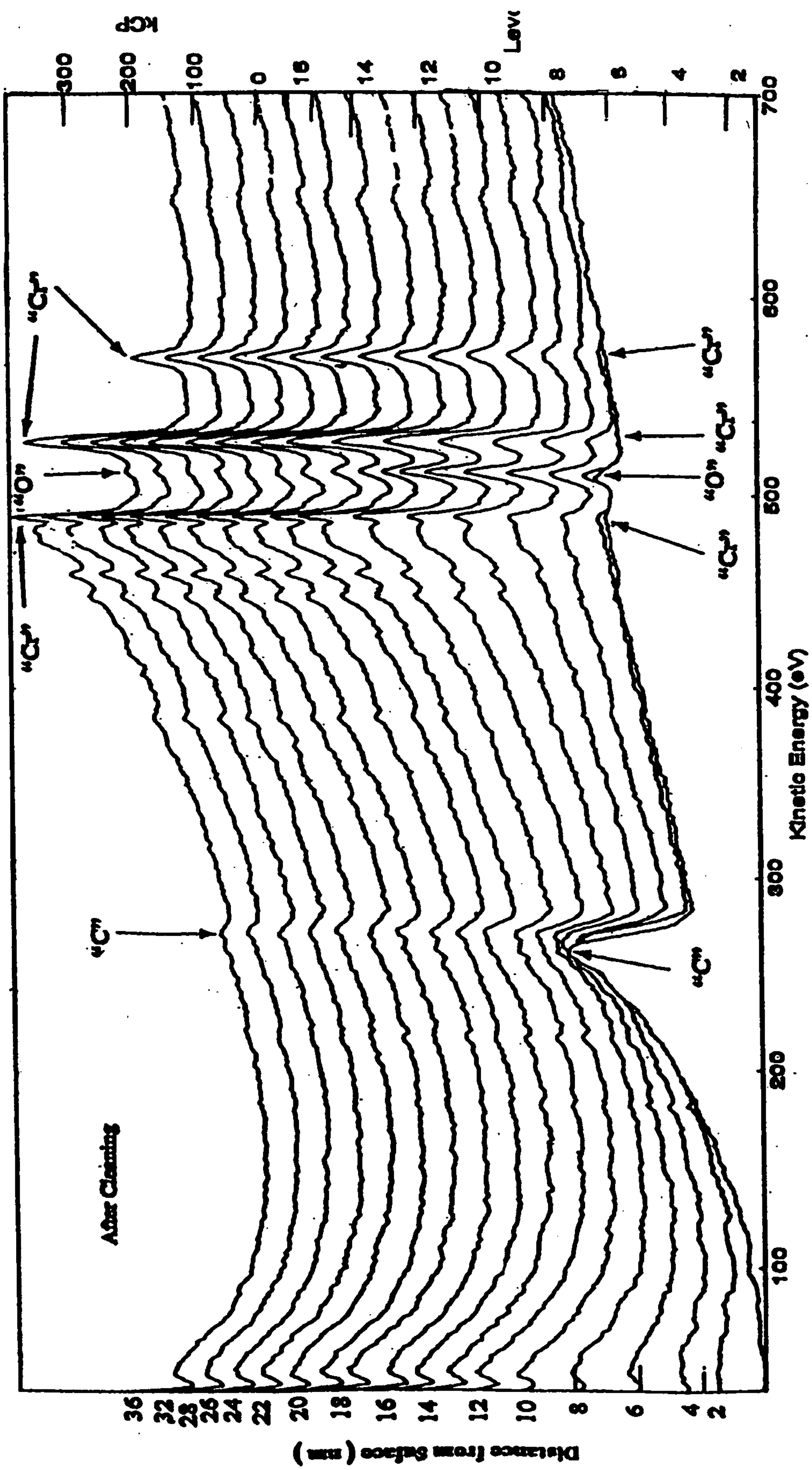

After Cleaning
"C"
"Cr"
"O"
Kinetic Energy (eV)
Distance from Surface (nm)
Level

FIG. 6

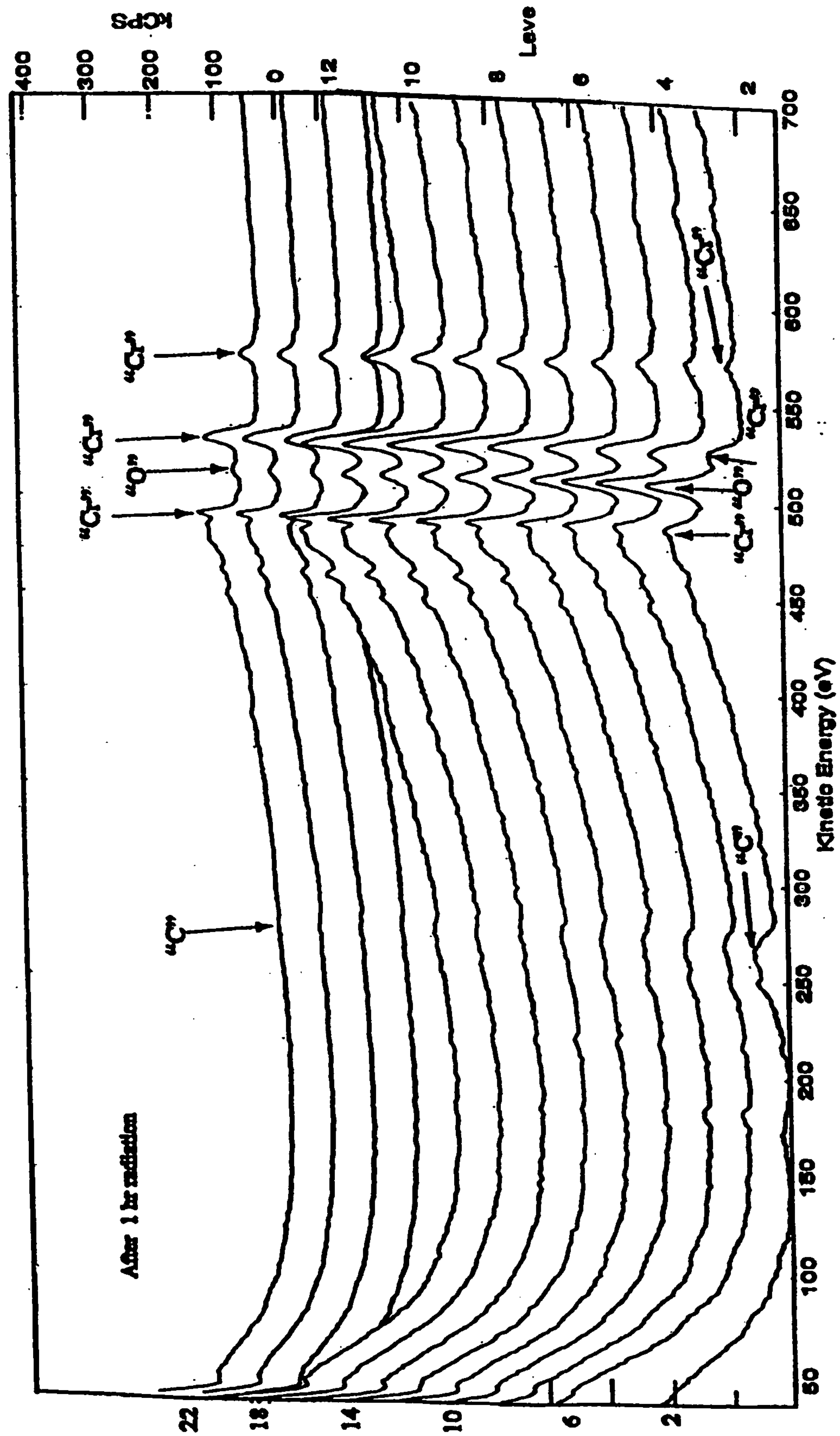

kCPS
400
300
200
100
Leve
0
12
10
8
6
4
2
"Cr"
"O"
"C"
After 1 hr radiation
22
18
14
10
6
2
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Kinetic Energy (eV)

FIG. 7